UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

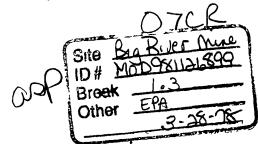**DATE**   March 28, 1978

SUBJECT   Chemical & Biological Analysis of the Big River

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INTRODUCTION

In January of 1977, the Surveillance and Analysis Division (SVAN) of the Environmental Protection Agency, Region VII, received a request from the Missouri Department of Natural Resources to conduct an intensive survey of the Big River from Leadwood, Missouri, to the Washington State Park   Since the late 1800's the land areas around the Big River, from Leadwood downstream, have been mined for lead and barium   During this time, mine tailings have entered the river and blanketed a stretch of the original river substrate

The intensive survey was to shed light on the following questions

1   Is the contaminated (degraded) stretch, evidenced by low (macrobenthos) species diversity from a previous study, extended beyond the original 40 mile stretch?

2   Is the degradation caused by substrate contamination (presumably dissolved toxic metals enveloping the mine tailing particles)?

3   What is the overall impact of seepage and runoff on water quality?

The proposed sampling effort, as outlined in the Big River Intensive Survey memorandum (August 15, 1977) was designed to answer these questions with the time and resources available   A comparison of the macrobenthos from BR-5 and BR-9 (Table 1, Figure 1) substrates would provide information for the first question   Water chemistry data, biological data from artificial substrates, and algal assay data, along with the result of the water flea (Daphnia magna) sediment toxicity test would provide information for the second and third questions

INTENSIVE SURVEY

On August 23, 1977, two periphytometers and three multiplate samplers were situated at each of the following stations   BR-1, BR-2, BR-3, BR-4, BR-5, and BR-6   On the same day, qualitative and quantitative macrobenthos and qualitative phytoperiphyton (attached algae) grab samples were collected from riffle areas at BR-5 and BR-9   The following day, water samples were collected at BR-1, BR-3, and BR-5 for chemical analysis and algal assays

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Sixteen days after the initial set-up, three glass slides were removed
from one of the two periphytometers at each station (except at BR-1),
placed in a preservative and returned to the laboratory for analysis
All five artificial substrates were missing from BR-1 and had to be
replaced Thirty-three days after the initial set-up, the multiplate
samplers were recovered from all six stations, preserved, and returned
to the laboratory Included in this sample collection were three glass
slides from BR-1

All biological phases of the survey, from set-up through analysis, were
performed in accordance with the procedures recommended in Biological
Field and Laboratory Methods (1973) Chemical analysis of the water
samples were in accordance with Methods for Chemical Analyses of Water
and Wastes (1974), and the algal assays were in accordance with the
Algal Assay Procedure Bottle Test (1971)

Based on the diversity (number of taxa) and the number of individual
macrobenthos found in the substrates of BR-5 (mine tailings) and BR-9
(natural substrate), the latter proved to be a more suitable habitat
Nearly 15 times as many organisms and twice the number of taxa were
collected from two square feet at BR-9 as compared to the same area
at BR-5 (Table 2) Although the BR-5 quantitative sample suggested a
substrate capable of supporting few taxa, the qualitative sample indi-
cated it does support a greater variety

Rock scrapings from BR-5 and BR-9 substrates were preserved and examined
for the relative abundance of attached algal groups (phytoperiphyton)
Phytoperiphyton, the predominant primary producer in shallow rivers,
is an excellent indicator of water quality Waters are considered
"healthy," or at least free from excessive amounts of decomposable
organic wastes when diatoms and green algae make up most of the phyto-
periphyton Diatoms and green algae (mostly diatoms) made up greater
than three-fourths of the attached algae at BR-5 and BR-9 (Table 3)
The BR-5 phytoperiphyton gave no indication of stress caused by dissolved
metals There was, however, evidence of disturbance caused by decompos-
able organic wastes Forty-seven percent of the BR-5 diatoms were nitrogen
heterotrophs (utilized organic nitrogen) In addition, virtually all
of the filamentous blue-greens (20 percent of the total phytoperiphyton)
were species of Oscillatoria and Lyngbya, two genera commonly associated
with organically enriched waters The BR-9 attached algae consisted
of fewer organic pollution indicators suggesting this point along the
Big River is in a recovery zone

Results of the algal assay indicated that on the day of sampling waters
at BR-1, BR-3, and BR-5, although phosphorus limited, were capable
of supporting moderate productivity Chemical analysis of water samples
from the same stations indicated significant increases in lead and zinc
between BR-1 and BR-3 (Table 4) These samples were collected the day
following an intense rainfall in the area and may reflect a significant
influence from runoff

The phytoperiphyton from the artificial substrates gave no indication of dissolved metal inhibition In fact, there was a progressive increase in productivity (cell numbers) between BR-1 and BR-4 with a gradual decrease between BR-4 and BR-6 (Table 5) Diatoms made up greater than 75 percent of the phytoperiphyton from each station with the exception of BR-2 5 (61 percent) At least one of the four most prominant diatoms at each station was an indicator of eutrophic (nutrient enriched) waters Curiously, Mougeotia, a filamentous green alga, comprised an unusually large portion (36 percent) of the phytoperiphyton at BR-2 5 Nitzschia palea, an obligate nitrogen heterotroph, made up greater than half of the diatoms at BR-4 This, plus the absence of a predominant nitrogen heterotroph at BR-3 indicated a source of organic pollution into the river between these two stations

Macrobenthos data from the multiplate samplers indicated little difference, diversity wise, between stations BR-1 through BR-6 (Table 6) The number of individuals, however, more than doubled between BR-2 5 and BR-3, and remained relatively high from BR-4 through BR-6 Station BR-1 had the fewest taxa and numbers, probably because of a shorter (two week) exposure period
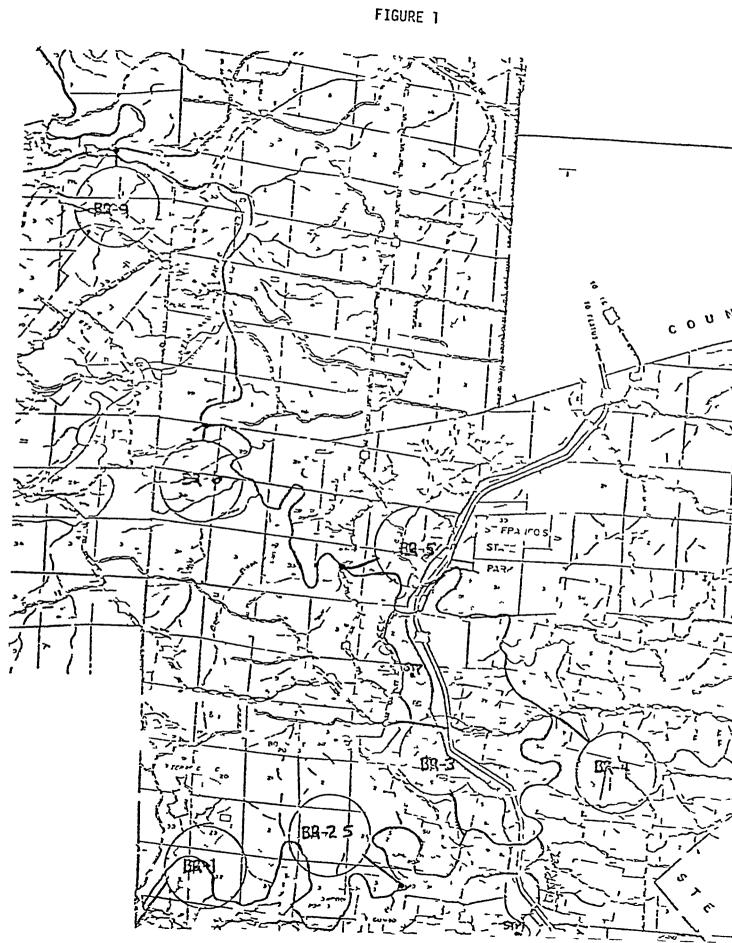
CONCLUSION

The depressed macrobenthos productivity in the mine tailing reach of the Big River is most likely the result of the abrasive action of the shifting sand and gravel substrate There are no indications that the mine tailings are toxic

It has been suggested that metal ions in mine tailings are removed from solution by some form of bonding to particulate material, detritus or bicarbonates, carried or transported to a site where equilibria result in release of toxic ions to contaminate a substrate Growth on the artificial substrates throughout the degraded reach indicated this was not happening Instead, productivity was significantly higher at each station compared to that of the control (BR-1) The fact that macrobenthos were found in the substrate at BR-5 and that the water flea sediment test, conducted earlier, did not indicate toxicants in the mine tailings further corroborates the theory that dissolved metals are not the cause of low productivity

Evidence of a change in water quality by runoff and/or point-source discharges was demonstrated by the phytoperiphyton The high number of organic pollution-indicating algae at BR-4 and BR-5 indicated one or more sources of organic loading upstream from both stations One source may be the Flat River Sewage Treatment Plant (STP) which discharges into the Flat River The Flat River confluences with the Big River between BR-3 and BR-4 Another source may be the Bonne Terre STP which discharges into Turkey Creek Turkey Creek empties into Big River between BR-4 and BR-5

A more detailed intensive survey of the Big River is recommended in the
near future to pinpoint the specific sources of organic pollution
Once located, these sources should be monitored for compliance

FIGURE 1

TABLE 1

Station	Location
BR-1	Big River at Highway 8 approximately 2 5 miles west of Leadwood, Missouri
BD-2 5	Big River at low water crossing at NW ¼ of section 35, T35N, R 4E
BR-3	Big River at Old Bonne Terre Road Bridge approximately 0 5 miles north of the northwest edge of Desloge, Mo
BR-4	Big River at County Road "K" approximately 2 miles east of Bonne Terre, Missouri
BR-5	Big River at County Road "E"
BR-6	Big River at ford approximately 0 5 miles past the end of Dickman Road (southwest corner of section 17 of T38N and R4E)
BR-9	Big River at State Road 21 near Washington State Park

TABLE 2

MACROBENTHOS DATA FROM NATURAL SUBSTRATES

	BR-5		BR-9	
	quan	qual	quan	qual
Taxa	12	28	23	32
No Indiv /Ft^2 (M^2)	19 (204)		282 (3040)	

RELATIVE ABUNDANCE

Diptera	39%	65/	45%	46%
Tan/tarsus spp	13%	25%	40/	21%
other midges	19%	35%	1%	21%
other dipterans	7%	5%	4/	4%
Tricnoptera	50%	23%	45%	6%
Coleoptera	5%	1%	1%	1%
Ephemeroptera	5%	10%	7%	46%
Odonata	0%	<1%	0%	<1%
Crustacea	0%	0%	<1%	1%
Oligochaeta	0%	0%	2%	1%
Others	0%	1%	1%	1%

TABLE 3

Relative Abundance of Big River Phyto-periphyton from Natural Substrates

	BR-5	BR-9
Diatoms	72%	69⁻
Filamentous Greens	3%	2ⁿ
Coccoid Greens	4%	14ₙ
Filamentous Blue-Greens	20%	12ⁿ
Coccoid Blue-Greens	<1%	<1%
Other Groups	0%	0/

Four Most Prominant Diatoms from Each Station

BR-5	BR-9
Nitzschia amphibia (40½)	Cymbella ventricosa (47/)
Nitzschia fonticola (8⁻)	Nitzschia amphibia (12½)
Nitzschia palea (7%)	Gomphonema olivaceum (8%)
Achnanthes lanceolata (7½)	Synedra ulna (8½)

	June 2, 1977			August 24, 1977		
	BR-1	BR-3	BR-5	BP-1	BR-3	BR-
Temperature (°C)	23 0	22 0	23 0	25 0	22 0	22
pH	7 8	8 0	8 0	7 8	8 0	7 8
Conductivity (μMHOS at 25°C)	--	--	--	385	400	480
Total Hardness (as CaCO₃)	--	--	--	171	176	202
Organic Nitrogen	3 30	<0 50	<0 50	<0 50	<0 50	<0 50
Total Ammonia	<0 04	<0 04	<0 04	0 32	0 06	0 16
Nitrites and Nitrates	<0 04	0 17	0 07	0 04	0 40	0 16
Total Soluble Phosphorus (OPO₄⁻)	--	--	--	<0 04	<0 04	0 05
Total Soluble Carbon	--	--	--	44	40	50
Aluminum	--	--	--	3736	2958	2484
Arsenic	--	--	--	0208	0093	0109
Barium	180	150	120	1484	1361	1246
Beryllium	--	--	--	< 000	< 000	< 000
Boron	--	--	--	06	08	07
Cadmium	--	--	--	0048	0048	0044
Calcium	--	--	--	37 87	40 88	47 76
Chromium	--	--	--	0121	0084	0099
Copper	< 005	< 005	< 005	0043	0094	0057
Iron, Total				3445	4162	3068
Iron, Dissolved				0461	0136	1049
Lead	< 005	028	080	0241	1370	0748
Magnesium	27	26	28	24 96	25 51	27 06
Manganese, Total	--	--	--	0882	0818	1141
Manganese, Dissolved	--	--	--	0163	0416	0738
Mercury				< 0002	< 0002	< 0002
Nickel	< 01	< 01	< 01	0024	0057	0083
Sodium	--			2 716	2 661	6 417
Zinc	030	203	044	0237	1922	0426

all values, unless otherwise indicated, are expressed as mg/l

TABLE 5

BIG RIVER PHYTO-PERIPHYTON DATA FROM ARTIFICIAL SUBSTRATES

	BR-1	BR-2 5	BR-3	BR-4	BR-5	BR-6
Cells/mm^2	1657	2886	4524	5034	3314	2544

RELATIVE ABUNDANCE

	BR-1	BR-2 5	BR-3	BR-4	BR-5	BR-6
Diatoms	84%	61%	84%	87%	86%	78%
Filamentous Greens	3%	36%	2%	1%	3%	8%
Coccoid Greens	8%	1%	5%	5%	3%	6%
Flagellated Greens	4%	0%	<1%	1%	2%	2%
Filamentous Blue-Greens	3%	1%	8%	6%	6%	5%
Coccoid Blue-Greens	<1%	1%	<1%	<1%	<1%	1%

NUMBER OF DIATOM SPECIES OBSERVED

	BR-1	BR-2 5	BR-3	BR-4	BR-5	BR-6
	31	28	18	20	23	34

(CONTINUED)

TABLE 5
(continued)

FOUR MOST PROMINANT DIATOMS

BR-1	BR-2 5	BR-3	BR-4	BR-5	BR-6
Navicula cryptocephala (25%)	Cymbella ventricosa (49%)	Cymbella ventricosa (59%)	Nitzschia palea (54%)	Achnanthes lanceolata (30%)	Nitzschia palea (16%)
Amphipleura pellucida (11%)	Synedra ulna (11%)	Achnanthes minutissima (10%)	Achnanthes lanceolata (9%)	Nitzschia palea (11%)	Synedra ulna (13%)
Nitzschia palea (10%)	Cymbella turgida (10%)	Navicula cryptocephala (8%)	Achnanthes minutissima (5%)	Cymbella ventricosa (10%)	Melosira varians (11%)
Synedra ulna (10%)	Cymbella prostrata (4%)	Cymbella undet sp (6%)	Cymbella turgida (5%)	Cyclotella memeghiniana (8%)	Gomphonema olivaceum (8%) & Navicula cryptocephala (8%)

TABLE 6

MACROBENTHOS DATA FROM ARTIFICIAL SUBSTRATES

	BR-1	BR-2 5	BR-3	BR-4	BR-5	BR-6
Taxa	20	24	23	22	26	32
No Indiv /Ft^2 (M^2)	236(2546)	288(3100)	710(7646)	417(4492)	440(4738)	595(6408)

RELATIVE ABUNDANCE

	BR-1	BR-2 5	BR-3	BR-4	BR-5	BR-6
Diptera	94%	97%	98%	97%	92%	93%
Tanytarsus spp	76%	46%	41%	49%	70%	68%
Other midges	18%	46%	56%	41%	20%	25%
Other diptera	0%	5%	1%	7%	2%	0%
Trichoptera	2%	<1%	1%	3%	1%	<1%
Coleoptera	<1%	0%	<1%	3%	<1%	<1%
Ephemeroptera	2%	<1%	0%	0%	6%	5%
Odonata	<1%	2%	0%	<1%	<1%	0%
Crustacea	0%	0%	0%	0%	0%	0%
Oligochaeta	0%	0%	0%	2%	<1%	0%
Others	<1%	<1%	0%	<1%	0%	<1%